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ENCLOSURES *(check all that apply)*

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Firm or Individual name	**Edward J. Kelly** **Customer Number 28120** **Ropes & Gray** **One International Place, Boston, MA 02110**
Signature	Edward J. Kelly
Date	**August 10, 2001**

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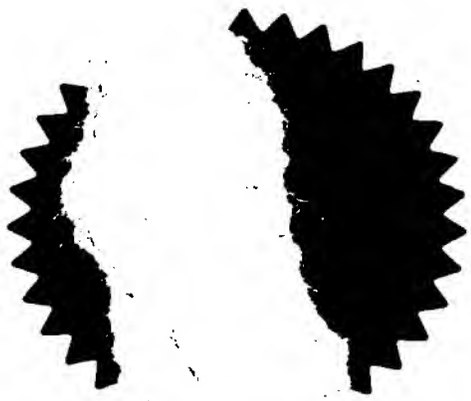

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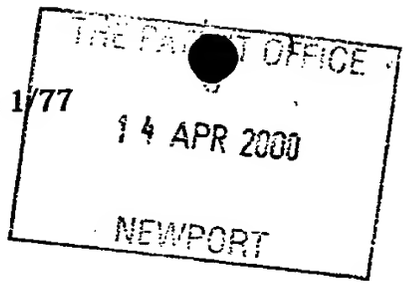

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3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Picsel Technologies Limited
Shaftesbury House
5 Waterloo Street
GLASGOW
G2 6AY

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

7878226001

4. Title of the invention

"Digital Document Processing"

5. Name of your agent *(if you have one)*

Murgitroyd & Company

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

373 Scotland Street
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G5 8QA

Patents ADP number *(if you know it)*

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Claim(s)	7
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Signature: Murgitroyd & Company — Date: 13 April 2000

12. Name and daytime telephone number of person to contact in the United Kingdom: John Cooper — 0141 307 8400

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"Digital Document Processing"

Field of the Invention

The invention relates to data processing systems. More particularly, the invention relates to methods and systems for processing "digital documents" (as defined herein) and to devices incorporating such methods and systems. In general terms, the invention is concerned with generating an output representation of a source document; e.g. as a visual display or as hardcopy.

Background to the Invention

As used herein, the term "digital document" is used to describe a digital representation of any type of data processed by a data processing system which is intended, ultimately, to be output in some form, in whole or in part, to a human user, typically by being displayed or reproduced visually (e.g. by means of a visual display unit or printer), or by text-to-speech conversion, etc. A digital document may include any

features capable of representation, including but not limited to the following: text; graphical images; animated graphical images; full motion video images; interactive icons, buttons, menus or hyperlinks. A digital document may also include non-visual elements such as audio (sound) elements.

Data processing systems, such as personal computer systems, are typically required to process "digital documents", which may originate from any one of a number of local or remote sources and which may exist in any one of a wide variety of data formats ("file formats"). In order to generate an output version of the document, whether as a visual display or printed copy, for example, it is necessary for the computer system to interpret the original data file and to generate an output compatible with the relevant output device (e.g. monitor, or other visual display device, or printer). In general, this process will involve an application program adapted to interpret the data file, the operating system of the computer, a software "driver" specific to the desired output device and, in some cases (particularly for monitors or other visual display units), additional hardware in the form of an expansion card.

This conventional approach to the processing of digital documents in order to generate an output is inefficient in terms of hardware resources, software overheads and processing time, and is completely unsuitable for low power, portable data processing systems, including wireless telecommunication systems, or for low cost

data processing systems such as network terminals, etc. Other problems are encountered in conventional digital document processing systems, including the need to configure multiple system components (including both hardware and software components) to interact in the desired manner, and inconsistencies in the processing of identical source material by different systems (e.g. differences in formatting, colour reproduction, etc). In addition, the conventional approach to digital document processing is unable to exploit the commonality and/or re-usability of file format components.

Summary of the Invention

It is an object of the present invention to provide digital document processing methods and systems, and devices incorporating such methods and systems, which obviate or mitigate the aforesaid disadvantages of conventional methods and systems.

The invention, in its various aspects, is defined in the Claims appended hereto. Further aspects and features of the invention will be apparaent from the following description.

In a first aspect, the invention relates to a digital document processing system comprising:

means for receiving an input bytestream representing source data in one of a plurality of predetermined data formats;

interpreting means for interpreting said bytestream;

converting means for converting interpreted content from said bytestream into an internal representation data format;

means for processing said internal representation data so as to generate output representation data adapted to drive an output device.

In a second aspect, the invention relates to a graphical user interface for a data processing system in which interactive visual displays employed by the user interface are generated by means of a digital document processing system in accordance with the first aspect of the invention and to data processing systems incorporating such a graphical user interface.

In further aspects, the invention relates to various types of device incorporating a digital document processing system in accordance with the first aspect of the invention, including hardware devices, data processing systems and peripheral devices.

In still another aspect, the invention relates to a graphical user interface for a data processing system, having one or more of a number of novel and/or enhanced features, and to data processing systems incorporating such a graphical user interface.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawing.

Brief Description of the Drawing

Fig. 1 is a block diagram illustrating an embodiment of a digital document processing system in accordance with the present invention.

Detailed Description of the Preferred Embodiments

Referring now to the drawings, a digital document processing system 8 embodying the invention is illustrated in Fig. 1.

In general terms, the system 8 will process a source document 10 comprising a data file in a known format. The input to the system 8 is a bytestream comprising the content of the source document. An input module 11 identifies the file format of the source document on the basis of any one of a variety of criteria, such as an explicit file-type identification within the document, from the file name (particularly the file name extension), or from known characteristics of the content of particular file types. The bytestream is input to a "document agent" 12, specific to the file format of the source document. The document agent 12 is adapted to interpret the incoming bytestream and to convert it into a standard format employed by the system 8, resulting in an internal representation 14 of the source data in a "native" format suitable for processing by the system 8. The system 8 will generally include a plurality of different document

agents 12, each adapted to process one of a corresponding plurality of predetermined file formats.

The system 8 may also be applied to input received from an input device such as a digital camera or scanner. In this case the input bytestream may originate directly from the input device, rather from a "source document" as such. However, the input bytestream will still be in a predictable data format suitable for processing by the system and, for the purposes of the invention, input received from such an input device may be regarded as a "source document".

The document agent 12 employs a library 16 of standard objects to generate the internal representation 14, which describes the content of the source document in terms of a collection of generic objects as defined in the library 16, together with parameters defining the properties of specific instances of the various generic objects within the document. It will be understood that the internal representation may be saved/stored in a file format native to the system and that the range of possible source documents 10 input to the system 8 may include documents in the system's native file format. It is also possible for the internal representation 14 to be converted into any of a range of other file formats if required, using suitable conversion agents (not shown).

The generic objects employed in the internal representation 14 will typically include: text, bitmap graphics and vector graphics (which may or may not be

animated and which may be two- or three-dimensional), video, audio, and a variety of types of interactive object such as buttons and icons. The parameters defining specific instances of generic objects will generally include dimensional co-ordinates defining the physical shape, size and location of the object and any relevant temporal data for defining objects whose properties vary with time (allowing the system to deal with dynamic document structures and/or display functions). For text objects, the parameters will normally also include a font and size to be applied to a character string. Object parameters may also define other properties, such as transparency.

The format of the internal representation 14 separates the "structure" (or "layout") of the documents, as described by the object types and their parameters, from the "content" of the various objects; e.g. the character string (content) of a text object is separated from the font, character size and dimensional parameters of the object; the image data (content) of a graphic object is separated from its dimensional parameters. This allows document structures to be defined in a very compact manner and provides the option for content data to be stored remotely and to be fetched by the system only when needed.

The internal representation 14 describes the document and its constituent objects in terms of "high-level" descriptions.

The internal representation data 14 is input to a parsing and rendering module 18 which generates a context-specific representation 20 or "view" of the document represented by the internal representation 14. The required view may be of the whole document or of part(s) (subset(s)) thereof. The parser/renderer 18 receives view control inputs 40 which define the viewing context and any related temporal parameters of the specific document view which is to be generated. For example, the system may be required to generate a zoomed view of part of a document, and then to pan or scroll the zoomed view to display adjacent portions of the document. The view control inputs 40 are interpreted by the parser/renderer 18 in order to determine which parts of the internal representation are required for a particular view and how, when and for how long the view is to be displayed.

The context-specific representation/view 20 is again expressed in terms of object types and parameters, using the library 16.

The parser/renderer 18 may also perform additional pre-processing functions on the relevant parts of the internal representation 14 when generating the required view 20 of the source document 10. The view representation 20 is input to a shape processor module 22 for final processing to generate a final output 24, in a format suitable for driving an output device 26 (or multiple output devices), such as a display device or printer.

The pre-processing functions of the parser/renderer 18 may include colour correction, resolution adjustment/enhancement and anti-aliasing. Resolution enhancement may comprise scaling functions which preserve the legibility of the content of objects when displayed or reproduced by the target output device. Resolution adjustment may be context-sensitive; e.g. the display resolution of particular objects may be reduced while the displayed document view is being panned or scrolled and increased when the document view is static.

There may be a feedback path 42 between the renderer/parser 18 and the internal representation 14; e.g. for the purpose of triggering an update of the content of the internal representation 14, such as in the case where the document 10 represented by the internal representation comprises a multi-frame animation.

The output representation 20 from the parser/renderer 18 expresses the document in terms of "primitive" objects. For each document object, the representation 20 preferably defines the object at least in terms of a physical, rectangular boundary box, the actual shape of the object bounded by the boundary box, the data content of the object, and its transparency.

The shape processor 22 interprets the representation 20 and converts it into an output frame format 24 appropriate to the target output device 26; e.g. a dot-map for a printer, vector instruction set for a

plotter, or bitmap for a display device. An output control input 44 to the shape processor 22 defines the necessary parameters for the shape processor 22 to generate output 24 suitable for a particular output device 26.

The shape processor 22 preferably processes the objects defined by the view representation 20 in terms of "shape" (i.e. the outline shape of the object), "fill" (the data content of the object) and "alpha" (the transparency of the object), performs scaling and clipping appropriate to the required view and output device, and expresses the object in terms appropriate to the output device (typically in terms of pixels by scan conversion or the like, for most types of display device or printer).

The shape processor 22 preferably includes an edge buffer which defines the shape of an object in terms of scan-converted pixels, and preferably applies anti-aliasing to the outline shape. Anti-aliasing is preferably performed in a manner determined by the characteristics of the output device 26 (i.e. on the basis of the control input 44), by applying a grey-scale ramp across the object boundary. This approach enables memory efficient shape-clipping and shape-intersection processes.

A look-up table may be employed to define multiple tone response curves, allowing non-linear rendering control (gamma correction).

The individual objects processed by the shape processor 22 are combined in the composite output frame 24. The quality of the final output can also be controlled by the user via the output control input 44.

The shape processor 22 has a multi-stage pipeline architecture which lends itself to parallel processing of multiple objects, or of multiple documents, or of multiple subsets of one or more document, by using multiple instances of the shape processor pipeline. The pipeline architecture is also easily modified to include additional processing functions (e.g. filter functions) if required. Outputs from multiple shape processors 22 may generate multiple output frames 24 or may be combined in a single output frame 24.

The system architecture is modular in nature. This enables, for example, further document agents to be added as and when required, to deal with additional source file formats. The modular architecture also allows individual modules such as the library 16, parser/renderer 18 or shape processor 22 to be modified or upgraded without requiring changes to other modules.

The system architecture as a whole also lends itself to parallelism in whole or in part for simultaneous processing of multiple input documents 10a, 10b etc. or subsets of documents, in one or more file formats, via one or more document agents 12, 12a. The integrated, modular nature of the system allows multiple instances of system modules to be spawned within a data processing system or device as and when required,

limited only by available processing and memory resources.

The potential for flexible parallelism provided by the system as a whole and the shape processor 22 in particular allows the display path for a given device to be optimised for available bandwidth and memory. Display updates and animations may be improved, being quicker and requiring less memory. The object/parameter document model employed is deterministic and consistent. The system is fully scalable and allows multiple instances of the system across multiple CPUs.

The parser/renderer 18 and shape processor 22 interact dynamically in response to view control inputs 40, in a manner which optimises the use of available memory and bandwidth. This applies particularly to re-draw functions when driving a visual display, e.g. when the display is being scrolled or panned by a user.

Firstly, the system preferably implements a scalable deferred re-draw model, such that the display resolution of a document view, or of one or more objects within a view, varies dynamically according to the manner in which the display is to be modified. As previously mentioned, this might typically involve an object being displayed at reduced resolution whilst being moved on-screen and being displayed at full resolution when at rest. The system may employ multiple levels of display quality for this purpose. Typically, this will involve pre-built, low resolution

bitmap representations of document objects and/or dynamically built and scaled bitmaps, with or without interpolation. This approach provides a highly responsive display which makes best use of available memory/bandwidth.

The interaction of the renderer/parser 18 and shape processor 22 preferably also involves dividing the page to be viewed into zones. Each zone has associated with it a list of all objects contained within or overlapping that zone. Re-draws can then be processed on the basis of the zones, so that the system need only process objects associated with the relevant zones affected by the re-draw. This approach facilitates parallel processing and improves efficiency and reduces redundancy. The use of zones also facilitates the use of the system to generate different outputs for different display devices (e.g. for generating a composite/mosaic output for display by an array of separate display screens).

The ability to process transparent objects is a significant feature of the system. However, this necessitates the use of off-screen buffering in the shape processor 22 in order to assemble a final output frame. Typically, an off-screen buffer will cover an area larger than the immediate display area, allowing a limited degree of panning/scrolling within the buffer area, but the entire buffer has to be re-centred and re-built when the required display moves outwith these limits. Preferably, the system improves the efficiency of such buffering processes by defining the buffer

content as an array of tiles, indexed in an ordered list. When the required display view moves outwith the buffer area, it is then only necessary to discard those tiles which are no longer required, build new tiles to cover the new area of the display and update the tile list. This is faster and more efficient than conventional buffering processes and facilitates the use of multiple buffering and off-screen caching. It also facilitates interruptable re-draw functions (e.g. so that a current re-draw may be interrupted and a new re-draw initiated in response to user input).

The zoning and tiling schemes described above are independent in principle but may be combined advantageously; i.e. zones may correlate with one or more tiles. Again this facilitates parallelism and optimises use of system resources.

The system preferably employs a device-independent colour model, suitably a luminance/chrominance model such as the CIE L*a*b* 1976 model. This reduces redundancy in graphic objects, improves data compressibility and improves consistency of colour output between different output devices. Device-dependent colour correction can be applied on the basis of the device-dependent control input 44 to the shape processor 22.

Fig. 1 shows the system having an input end at which the source bytestream is received and an output end where the final output frame 24 is output from the system. However, it will be understood that the system

may include intermediate inputs and outputs at other intermediate stages, such as for fetching data content or for saving/converting data generated in the course of the process.

The system 8 may be incorporated into a variety of types of data processing systems and devices, and into peripheral devices, in a number of different ways. In a general purpose data processing system (the "host system"), the system of the present invention may be incorporated alongside the operating system and applications of the host system or may be incorporated fully or partially into the host operating system.

For example, the system of the present invention enables rapid display of a variety of types of data files on portable data processing devices with LCD displays without requiring the use of browsers or application programs. This class of data processing devices requires small size, low power processors for portability. Typically, this requires the use of advanced RISC-type core processors designed into ASICs (application specific integrated circuits), in order that the electronics package is as small and highly integrated as possible. This type of device also has limited random access memory and typically has no non-volatile data store (e.g. hard disk). Conventional operating system models, such as are employed in standard desktop computing systems (PCs), require high powered central processors and large amounts of memory in order to process digital documents and generate useful output, and are entirely unsuited for this type

of data processing device. In particular, conventional systems do not provide for the processing of multiple file formats in an integrated manner. By contrast, the present invention utilises common processes and pipelines for all file formats, thereby providing a highly integrated document processing system which is extremely efficient in terms of power consumption and usage of system resources.

The system of the present invention may be integrated at the BIOS level of portable data processing devices to enable document processing and output with much lower overheads than conventional system models. Alternatively, the invention may be implemented at the lowest system level just above the transport protocol stack. For example, the system may be incorporated into a network device (card) or system, to provide in-line processing of network traffic (e.g. working at the packet level in a TCP/IP system).

In a particular device, the system of the invention is configured to operate with a predetermined set of data file formats and particular output devices; e.g. the visual display unit of the device and/or at least one type of printer.

Examples of portable data processing devices which may employ the present system include "palmtop" computers, portable digital assistants (PDAs, including tablet-type PDAs in which the primary user interface comprises a graphical display with which the user interacts directly by means of a stylus device), internet-enabled

mobile telephones and other communications devices, etc.

The system may also be incorporated into low cost data processing terminals such as enhanced telephones and "thin" network client terminals (e.g. network terminals with limited local processing and storage resources), and "set-top boxes" for use in interactive/internet-enabled cable TV systems.

When integrated with the operating system of a data processing system, the system of the present invention may also form the basis of a novel graphical user interface (GUI) for the operating system (OS). Documents processed and displayed by the system may include interactive features such as menus, buttons, icons etc. which provide the user interface to the underlying functions of the operating system. By extension, a complete OS/GUI may be expressed, processed and displayed in terms of system "documents". The OS/GUI could comprise a single document with multiple "chapters".

The system enables and/or facilitates a variety of novel and/or enhanced GUI features, including, but not limited to, the following:

- The use of thumbnail images of documents for navigation purposes and for recording user activities (history); e.g. when browsing network content.

- Document interaction functions and gesture-based commands using pointing devices and/or touch-screen technology; e.g.:
  allowing document interaction by means of gestures analogous to actions used with physical documents or books, such as dragging a pointer across a page in order to turn the page ("page-flipping"), dragging a pointer to curl back the corner of a page to view underlying parts of succeeding pages ("page curl");
  allowing tool selection by dragging tools from toolbars and de-selection by dragging tools to predetermined parts of the display;
  symbolic cursor movements to indicate particular OS commands, such as "tick", "cross-out" and "circle" movements for "OK", "delete" and "select"; editing commands based on conventional "proof-readers" notation;
- Re-formatting document views by rotation or switching between landscape and portrait formats;
- Utilities and tools such as:
  a floating virtual "magnifying glass" which magnifies the underlying document area, in which the magnified view is based on the internal representation 14 of the source document rather than on a bitmap representation of the document and which may modify document parameters such as background and/or foreground colours;
  a floating virtual, translucent keyboard for text input using a pointing device/touch screen;

a floating, virtual, translucent ruler which is re-scalable using any of a variety of user-selectable units.

- Alternative menu or "tabbed page" drag out/pull down functions.
- Simulation of physical inertia/momentum applied to page scrolling/panning functions (e.g. when a zoomed display of a page is dragged to scroll the display and released, the moving display decelerates gradually after release).

GUI features of this type provide new or enhanced functionality and/or improve the subjective quality of the user interface.

The system of the present invention may also be incorporated into peripheral devices such as hardcopy devices (printers and plotters), display devices (such as digital projectors), networking devices, input devices (cameras, scanners etc.) and also multi-function peripherals (MFPs).

When incorporated into a printer, the system enables the printer to receive raw data files from the host data processing system and to reproduce the content of the original data file correctly, without the need for particular applications or drivers provided by the host system. This avoids the need to configure a computer system to drive a particular type of printer. The present system directly generates a dot-mapped image of the source document suitable for output by the printer (this is true whether the system is incorporated into

the printer itself or into the host system). Similar considerations apply to other hardcopy devices such as plotters.

When incorporated into a display device, such as a projector, the system again enables the device to display the content of the original data file correctly without the use of applications or drivers on the host system, and without the need for specific configuration of the host system and/or display device. Peripheral devices of these types, when equipped with the present system, may receive and output data files from any source, via any type of data communications network.

From the foregoing, it will be understood that the system of the present invention may be "hard-wired; e.g. implemented in ROM and/or integrated into ASICs or other single-chip systems, or may be implemented as firmware (programmable ROM such as flashable ePROM), or as software, being stored locally or remotely and being fetched and executed as required by a particular device.

Improvements and modifications may be incorporated without departing from the scope of the present invention.

Claims

1. A digital document processing system comprising:

means for receiving an input bytestream representing source data in one of a plurality of predetermined data formats;

interpreting means for interpreting said bytestream;

converting means for converting interpreted content from said bytestream into an internal representation data format;

means for processing said internal representation data so as to generate output representation data adapted to drive an output device.

2. A system as claimed in Claim 1, wherein said source data defines the content and structure of a digital document, and wherein said internal representation data describes said structure in terms of generic objects defining a plurality of data types and parameters defining properties of specific instances of generic objects, separately from said content.

3. A system as claimed in Claim 2, further including a library of generic objects, said internal representation data being based on the content of said library.

4. A system as claimed in Claim 2 or Claim 3, including a parsing and rendering module adapted to generate an object and parameter based representation

of a specific view of at least part of said internal representation data, on the basis of a first control input to said parsing and rendering module.

5. A system as defined in Claim 4, further including a shape processing module adapted to receive said object and parameter based representation of said specific view from said parsing and rendering module and to convert said object and parameter based representation into an output data format suitable for driving a particular output device.

6. A system as claimed in Claim 5, wherein said shape processing module processes said objects on the basis of a boundary box defining the boundary of an object, a shape defining the actual shape of the object bounded by the boundary box, the data content of the object and the transparency of the object.

7. A system as claimed in Claim 6, wherein said shape processor is adapted to apply grey-scale anti-aliasing to the edges of said objects.

8. A system as claimed in Claim 5, Claim 6 or Claim 7, wherein said shape processing module has a pipeline architecture.

9. A system as claimed in any one of Claims 5 to 8, wherein said shape processor employs at least one off-screen display buffer to generate said output data and wherein said at least one off-screen display buffer is defined by an indexed array of tiles.

10. A system as defined in Claim 9, wherein updating of the content of said at least one off-screen display buffer is performed by removing selected tiles from said array, adding new tiles to said array, and updating the indexing of said tiles.

11. A system as claimed in any one of Claims 5 to 10, wherein said parsing and rendering module is adapted to define at least part of said internal representation data it terms of a plurality of zones, each zone having an associated list of objects contained within and overlapping said zone, and said shape processor is adapted to process said object and parameter based representation on the basis of said zones and associated lists.

12. A system as claimed in any one of Claims 5 to 11, wherein the quality of a display view represented by said output data may be varied dependent on said first control input.

13. A system as claimed in Claim 12, wherein the quality of said display view may be varied in multiple steps.

14. A system as claimed in any one of Claims 2 to 13, wherein said object parameters include dimensional, physical and temporal parameters.

15. A system as claimed in any preceding Claim, wherein the system employs a chrominance/luminance-based colour model to describe colour data.

16. A system as claimed in any preceding Claim, wherein the system is adapted for multiple parallel implementation in whole or in part for processing one or more sets of source data from one or more data sources and for generating one or more sets of output representation data.

17. A graphical user interface for a data processing system in which interactive visual displays employed by the user interface are generated by means of a digital document processing system as claimed in any one of Claims 1 to 16.

18. A data processing device incorporating a graphical user interface as claimed in Claim 17.

19. A hardware device for data processing and/or storage encoding a digital document processing system as claimed in any one of Claims 1 to 16.

20. A hardware device as claimed in Claim 19, further including a core processor system.

21. A hardware device as claimed in Claim 20, wherein said core processor is a RISC processor.

22. A data processing system including a digital document processing system as claimed in any one of Claims 1 to 16.

23. A data processing system as claimed in Claim 22, wherein said data processing system comprises a portable data processing device.

24. A data processing system as claimed in Claim 23, wherein said portable data processing device comprises a wireless telecommunications device.

25. A data processing system as claimed in Claim 22, wherein said data processing system comprises a network user-terminal.

26. A peripheral device for use with a data processing system, including a digital document processing system as claimed in any one of Claims 1 to 16.

27. A peripheral device as claimed in Claim 26, wherein said peripheral device is a visual display device.

28. A peripheral device as claimed in Claim 26, wherein said peripheral device is a hardcopy output device.

29. A peripheral device as claimed in Claim 26, wherein said peripheral device is an input device.

30. A peripheral device as claimed in Claim 26, wherein said peripheral device is a network device.

31. A peripheral device as claimed in Claim 26, wherein said peripheral device is a multi-function peripheral device.

32. A graphical user interface for a data processing system, including at least one of the following features:

- the use of thumbnail images of documents for navigation purposes and for recording user activities;
- document interaction functions and gesture-based commands using pointing devices and/or touch-screen technology, including document interaction by means of gestures analogous to actions used with physical documents or books;
- tool selection by dragging tools from toolbars and de-selection by dragging tools to predetermined parts of the display;
- symbolic cursor movements to indicate commands;
- re-formatting document views by rotation or switching between landscape and portrait formats;
- alternative menu or "tabbed page" drag out/pull down functions.
- simulated physical inertia/momentum applied to page scrolling/panning functions.

33. A graphical user interface for a data processing system, including at least one of the following utilities/tools:

- a floating virtual magnifying glass adapted to magnify an underlying document area, in which the magnified view is based on source document data;

- a floating virtual, translucent keyboard for text input using a pointing device/touch screen;
- a floating, virtual, translucent ruler which is re-scalable using any of a variety of user-selectable units.

34. A data processing system incorporating a graphical user interface as claimed in Claim 32 or Claim 33.

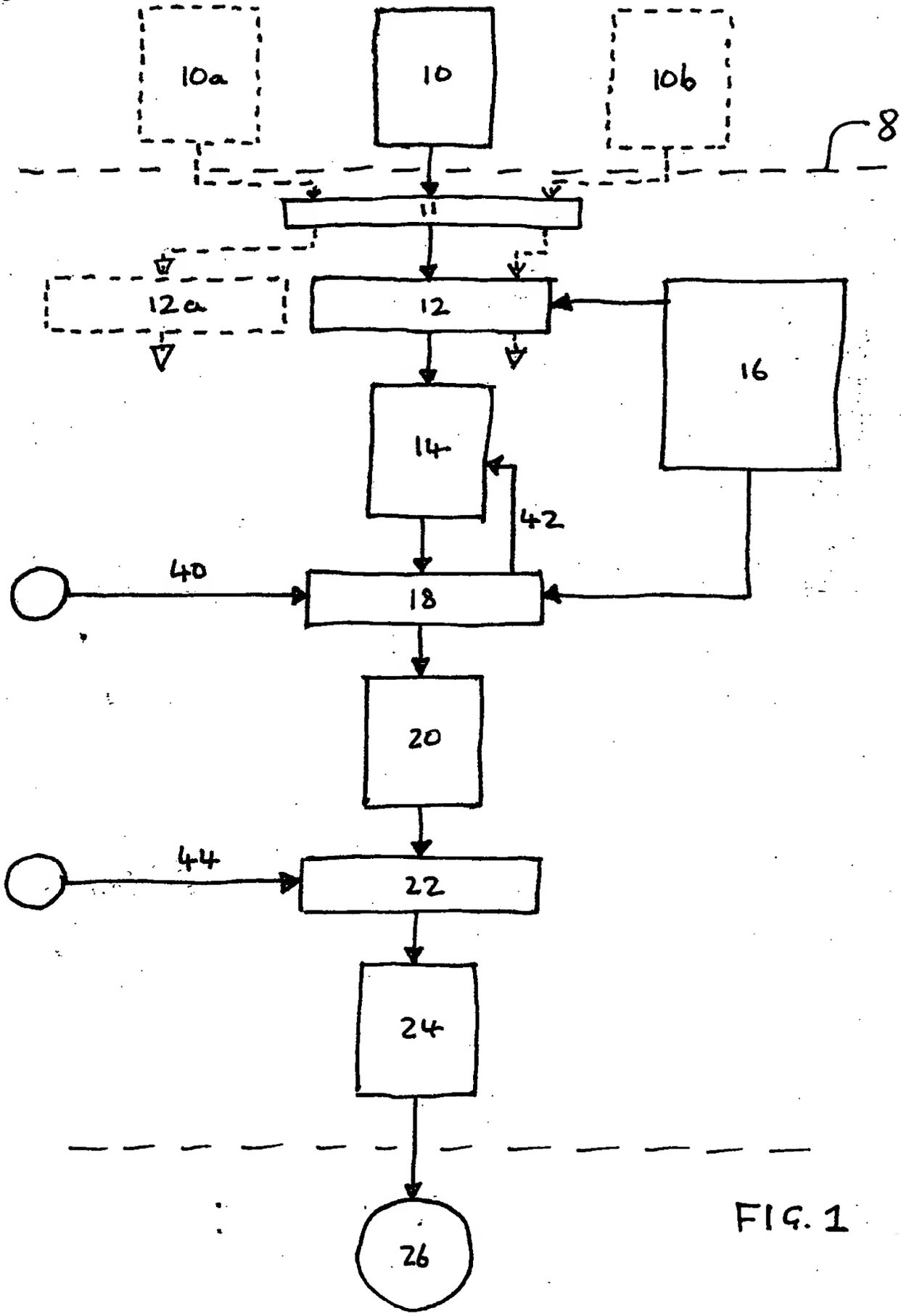

FIG. 1